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# **THE 1994 NORTHRIDGE EARTHQUAKE AND THE FIRES THAT FOLLOWED**

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## **ABSTRACT**

The purpose of this paper is to provide an overview of the fire problem that occurred as a result of the January 17, 1994, Northridge Earthquake. A brief review of the factors involved in ignition, spread, response and suppression operations will lead into discussions concerning the fires that followed the 6.8M earthquake and analysis of what was learned.

## **I. INTRODUCTION - FIRE FOLLOWING EARTHQUAKE**

Fires that occur as a result of the damage caused by earthquakes are but one of many consequences of the shaking. Large fires following an earthquake in urban areas are relatively rare but have occasionally been of catastrophic proportions. The two largest peace time urban fires from earthquakes were the 1906 San Francisco and 1923 Tokyo disasters.

The January 17, 1995 Kobe Japan Earthquake resulted in major losses as a result of the fires that swept many residential and commercial neighborhoods. It is estimated that over 6,500 buildings were burned totalling nearly 700,000 square meters of area.

There are many factors involved in contributing to the magnitude of the fire problem following an earthquake.

### Ignition

Post earthquake ignitions occur from many forces caused by the shaking intensity such as breakage, open flame, chemical reaction, electrical wiring, friction and other factors. The number of ignitions can be related to shaking intensity and building density, construction and occupancy type.

Multiple ignitions will overwhelm the ability of the Fire Department to respond and potentially lead to conflagrations.

### Fire Report and Response

Locating and reporting fires following the earthquake is problematic due to the damage created and concurrent loss of normal communications systems. Delays in response result in fire spread and as these fires grow it will eventually take more suppression resources to control them. Mutual Aid fire companies were requested from outside Los Angeles County.

### Fire Growth and Spread

Fire growth and spread may be related to building density, open spaces, construction, contributing materials such as natural gas, flammable chemicals, other combustible fuel, and of course weather conditions. Wind speed is the most critical factor in fires considered of conflagration proportions.

### Fire Suppression

Rapid response and access to the fire is critical to controlling the growth of fire. Response may be made by convergent or trained volunteers, and professional firefighters. Building sprinkler systems may also be part of the suppression equation if they are not damaged and if water is available. Of primary concern is the availability of water for firefighting since this is a system commonly damaged in large earthquakes. Initial firefighting operations will be impacted by other response priorities such as structural collapse rescue and immediate evacuation of areas threatened by fast moving fires or hazardous chemical spills. The priority for emergency responders is saving lives with the protection of property as a secondary priority.

## **II. The Northridge Earthquake - An Overview**

At 0431 hours on January 17, 1994, the Los Angeles area was rocked by an earthquake whose damage in recent history was preceded only by the San Francisco Earthquake in 1906. The Northridge Earthquake registered 6.8Mw on a thrust fault 12 miles beneath the San Fernando Valley. The earthquake resulted in 57 deaths, over 9,000 injuries and losses exceeding \$20 billion.

Peak ground accelerations were measured at 1.8g and over 58,000 buildings were damaged. The City's infrastructure was badly damaged including the loss of electrical power and thousands of breaks in natural gas lines, and water mains.

The City was in total darkness from the loss of power and initial damage assessment was difficult for emergency response personnel. Telephone communications were compromised from damage and overuse resulting in delays to many emergency incidents.

## **III. Fires**

Department resources, confronted with significant obstacles such as total darkness, inadequate water pressure, electrical hazards, and roadways blocked with debris, were effectively utilized in rapidly controlling fires, using quick known down tactics, preventing extension to exposed structures, and moving on to the next prioritized incident.

Due to water shortages, 29 water tank trucks were requested through the Statewide Fire Department Mutual Aid System and were strategically located with fire companies to respond as an added resource. Swimming pools were also effectively utilized as a water supply for firefighting. Fire Department water dropping helicopters were even used in dropping over 15,000 gallons of water on structure fires which is not a standard operational procedure.

During the first 27 hours and 29 minutes (0431 hours on January 17, 1994, to 0800 hours on January 18, 1994) following the earthquake, 2,332 incidents were created in the Fire Department dispatch center. The average number of incidents in a 24-hour period is about 900. There were actually more incidents handled by LAFD resources during the peak incident time period but not reported.

The summary of incidents for this 27-1/2 hours is as follows:

776 incidents or 33.3% were fire incidents

1,111 incidents or 47.6% were EMS incidents

445 incidents or 19.1% were other incidents

Due to the unusually high number of incidents reported immediately after the earthquake, the Fire Department dispatch center (OCD) reduced the number and types of resources dispatched to each. Eight minutes after the earthquake, dispatch assignments of Department resources were degraded to the earthquake mode. Three minutes later, assignments were further degraded to the disaster mode. In the disaster mode there is a major assignment reduction with 13 no send fire categories. The Department remained in the disaster mode until 2119 hours on January 18, 1994.

Many of the structure fires that occurred during this time frame resulted in the utilization of minimal Department resources. During normal operations, many of these structure fires would have utilized many more resources, and been classified as major emergencies. Fire Department Command established strategy to prevent incidents from reaching catastrophic proportions. Incidents were prioritized by field officers to mitigate the potential for conflagrations. For those incidents that exceeded available resource capability, emphasis was placed on exposure protection.

The most common types of incidents created on January 17 and 18, 1994, falling within the fire category are listed below:

<u>Incident Type</u>	<u>Number of Incidents Created</u>	<u>Percent of Total Fire Incidents</u>
Reported Structure Fires	660	85.0%
Brush/Grass/Trees	38	4.9%
Rubbish Fires	17	2.2%
Pole Fires	17	2.2%
Automobile Fires	14	1.8%
Automatic Alarms	12	1.5%
Illegal Burning	12	1.5%

Other incidents in this category bring the total to 100%.

As a result of investigations conducted by the LAFD Arson Section after the earthquake, it was determined that 158 actual structure fires occurred during the 27-1/2 hour period following the initial shock. This number accounts for fires occurring at a single address and does not include the multiple fires that occurred within a mobile home park. The fires were scattered throughout the City of Los Angeles, with the majority of the incidents occurring closest to the epicenter of the earthquake. Further complicating fire suppression efforts were damage to water mains, inadequate water pressure, and collapsed structures. A brief synopsis of some of the structure fires follows:

11611 Blucher Avenue - January 17, 1994, 0431 hours

The collapse of a two-story apartment complex over carport resulted in the structure crushing numerous automobiles. A fire started in the carport at the onset of the earthquake. Due to the condition of the structure and the potential for further collapse, the fire extended into the apartments. Loss estimated at \$1,500,000.

18110 Andrea Circle North - January 17, 1994, 0431 hours

A fire, determined to originate at the gas meter, extended to 17 units in three separate buildings in a multiple unit, apartment complex. Loss estimated at \$500,000.

18111 W. Nordoff Street, Building 2, Cal State Northridge - January 17, 1994

Two separate fires and chemical spills were discovered on the second and third floors of the three-story, 75 x 200 foot science building of the Cal State Northridge Campus. The fire rooms contained unknown types and amounts of chemicals. The cause of the fire is undetermined at this time.

16700 Chatsworth Street - January 17, 1994, 0432 hours

A fire resulting from combustibles placed too close to a heat source resulted in the destruction of 14 units in three buildings of an apartment/condominium complex. No loss was estimated.

19155 Victory Boulevard - January 17, 1994

A fire originating from a natural gas leak resulted in the total burnout of a 50 x 150 foot apartment/condominium complex. No loss was estimated.

15455 Glenoaks Boulevard - January 17, 1994, 0434 hours

Earthquake caused a break or leak in natural gas lines resulting in the destruction of 58 mobile homes. Loss estimated at \$5,000,000.

13320 Riverside Drive - January 17, 1994, 0435 hours

A fire in a machinery room on the roof of a two-story medical building caused \$250,000 damage. The investigation determined that the fire was a result of a broken natural gas line to a water heater that was knocked over by the shock of the earthquake.

15831 Olden Street - January 17, 1994, 0435 hours

A fire determined to be the result of leaking natural gas destroyed 22 mobile homes at a mobile home park. No loss was estimated.

19240 Dearborn Street - January 17, 1994, 0440 hours

A fire originating from a broken natural gas line at the water heater resulted in a complete burnout of a single-family dwelling. Loss estimated at \$400,000.

21001 Plummer Street, #61 - January 17, 1994, 0440 hours

A fire, of undetermined origin, occurred in a mobile home resulting in the fatality of a 90-year old female.

2741 S. Palm Grove Avenue - January 17, 1994, 0440 hours

A fire originating immediately after the earthquake at the natural gas meter resulted in a \$250,000 loss to a multiple unit residence.

365 West 47th Place - January 17, 1994, 0453 hours

Shock of the earthquake caused the natural gas flex line to a clothes dryer located on a service porch of a single-family dwelling to rupture causing natural gas to leak into dwelling. Gas was ignited by a pilot light in the kitchen. Loss estimated at \$140,000.

15445 Cobalt Way - January 17, 1994, 0500 hours

Several fires, originating in separate mobile homes, eventually destroyed 54 mobile homes in a mobile home park. The fires originated as a result of natural gas leaks following the earthquake. Loss estimate at \$1,500,000.

17221 West Willard Street - January 17, 1994, 0500 hours

A fire involving a single-family dwelling originated when a block wall fell, as a result of the earthquake, onto the gas meter shearing the riser at ground level. The natural gas was ignited from unknown sources entering the structure. Loss estimated at \$50,000.

5622 N. El Canon Avenue - January 17, 1994, 0501 hours

Fire in a single-family dwelling occurred when a shelf, located above a water heater, broke away from the wall and dropped material. The material apparently broke the gas line leading to the water heater regulator which eventually ignited the material. Loss estimated at \$250,000.

11700 N. Balboa Boulevard - January 17, 1994, 0527 hours

A break in a 12-inch underground natural gas main resulted in destroying five single-family dwellings and damaging one other. Loss estimated at \$1,500,000.

2324 S. Chariton Street - January 17, 1994, 0530 hours

Fire originating from a broken natural gas connection to a floor furnace in a single-family dwelling extended vertically through the walls and into the attic. Loss was estimated at \$200,000.

14011 Ventura Boulevard - January 17, 1994, 0530 hours

A fire of undetermined origin caused an estimated \$500,000 worth of damage to a two-story, multi-unit commercial structure. Fire appeared to originate on the second floor.

3845 N. Bobstone Drive - January 17, 1994, 0533 hours

Structure fire in a single-family dwelling. Probable cause was determined to be a natural gas leak due to the earthquake. Loss estimated at \$400,000.

634 O'Melveny Avenue - January 17, 1994, 0613 hours

Earthquake caused a rupture in a crude oil pipeline causing oil to flow and burn in the street. One single-family dwelling and 15 vehicles destroyed, and two single-family dwellings damaged. Loss estimated at \$2,500,000.

4360 N. Ventura Canyon Avenue - January 17, 1994, 0643 hours

Structure fire in a collapsed, two-story, 14-unit apartment with underground parking, 40 x 150 feet in dimension. Fire involved several units in the rear of the complex. Unable to determine cause due to the building collapse. No estimated loss.

10630 N. Louise Avenue - January 17, 1994, 0652 hours

A fire, of undetermined origin, occurred in a single-family dwelling. Fire exposed a second single-family dwelling located at 10636 N. Louise Avenue resulting in the total loss of that structure. Loss estimated at \$400,000.

13320 W. Riverside Drive - January 17, 1994, 0740 hours  
Fire originating in the machinery room of a three-story medical office building resulted in an estimated \$500,000 loss. Probable cause was a natural gas leak.

7225 W. Hollywood Boulevard - January 17, 1994, 0813 hours  
Incendiary fire in one unit of a 74-unit apartment hours. No estimated loss.

9250 W. Owensmouth Avenue - January 17, 1994, 0843 hours  
Undetermined fire in a 50 x 250 foot metal clad commercial occupancy. Loss estimated at \$500,000.

1818 S. Stoner Avenue - January 17, 1994, 0844 hours  
Fire in one unit of a 16-unit apartment house. Cause was determined to be an electrical lamp that was knocked over during the earthquake onto clothing. Heat from lamp ignited clothing when power restored.

18111 W. Nordoff Street, Building 3, Cal State Northridge - January 17, 1994  
A second fire and chemical spill resulting from broken/spilled chemical containers co-mingling as a result of the earthquake occurred on the third floor of a three-story, 75 x 200 foot science building on the Cal State Northridge Campus. The loss was estimated at \$50,000.

18111 W. Nordoff Street, Building 1, Cal State Northridge - January 17, 1994  
A third fire and chemical spill on the Cal State Northridge Campus occurred on the third floor of Science Building 1. The fire, similar to the fire that occurred in Building 3, was a result of a chemical reaction with broken/spilled chemicals. The loss was estimated at \$50,000.

1118 W. 3rd Street - January 17, 1994, 0931 hours  
Structure fire in a single-family dwelling caused by a broken flex natural gas line at the water heater. Fire extended to two, four-unit apartment houses. Loss estimated at \$500,000.

11275 Westminster Avenue - January 17, 1994, 1102 hours  
Fire occurred in a multi-unit apartment complex due to natural gas leak in line leading from meters to apartments. Break in line due to earthquake. Natural gas found source of ignition in apartment complex. Loss estimated at \$125,000.

19360 Rinaldi Street - January 17, 1994, 1216 hours  
The earthquake caused an air conditioning unit on the roof of a single-story commercial occupancy to knock over causing the motor to eventually burnout and short. Air conditioning unit caught fire and spread to the structure. No loss estimated.



17515 W. Enadia Street - January 17, 1994, 1230 hours

A fire in the garage of a single-family dwelling occurred shortly after the electricity was restored to the area. Loss estimated at \$105,000.

12021 Riverside Drive - January 17, 1994, 1400 hours

A fire causing \$400,000 in damage occurred in a two-story dental office. An investigation determined the fire was caused by an electrical short in the attic area originating when the power was restored to the area.

14025 Ventura Boulevard - January 17, 1994, 1842 hours

A fire of undetermined cause, resulted in the destruction of the entire second floor of a multi-occupancy commercial. The fire originated on the second floor and resulted in a \$1,500,000 loss.

"Other" type incidents created on January 17 and 18, 1994:

<u>Incident Type</u>	<u>Number of Incidents Created</u>	<u>Percent of Total Fire Incidents</u>
Leaking Natural Gas	126	28.3%
Electrical/Wires Down	99	22.2%
Hazardous Conditions	99	22.2%
HazMat/Chem Investigations	45	10.1%
Water Problems	44	9.8%
Elevators	13	2.9%
Invalid Assists	8	1.8%

Other incidents in this category bring the total to 100%

There were 445 incidents created within this category. Although not reported as actual fire incidents, these incidents required the dispatch of fire suppression resources.

The largest number of incidents created in this group was due to reported natural gas leaks (approximately 28.3% of the total within this group). The figures for actual natural gas services shut down by LAFD personnel are not available.

Many buildings, throughout the entire City of Los Angeles, sustained total or partial collapse from the initial January 17, 1994, earthquake and from the subsequent aftershocks. Structural damage, although related to the distance from the epicenter, was scattered indiscriminately throughout the Southern California region. Given the intensity of the earthquake, the time of day, and the number of buildings that collapsed, the number of deaths resulting from the collapse of buildings was remarkably small.

## VI. Analysis

Fire following earthquake will continue to be a factor for emergency responders and disaster planners. Much needs to be done in researching areas such as ignition sources, spread factors, and fire modelling in order to mitigate against their destructive impact.

Scientists predict that Southern California faces an 86% chance of a magnitude 7 or greater earthquake by the year 2024. As a result of the Northridge Earthquake, several actions were taken by the City of Los Angeles to assist in the control of future fires following earthquakes. A City ordinance was enacted calling for the installation of automatic gas shut off valves on structures. Studies are underway on pipeline safety, mobile home anchoring systems, auxiliary water supply, and controlling re-energizing the electrical systems in damaged buildings/areas.

The potential for major post earthquake fires in the United States clearly exists in the New Madrid (Central United States) and Puget Sound (Pacific Northwest) seismic zones, as well as in California. Research into prevention and mitigation of these fires is crucial if future catastrophes are to be avoided.

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Frank Borden

## ***Discussion***

Edward Zukoski: I'd like to address a question to you and the previous speaker. Would the use of the kind of cisterns in Japan be of any help to us in Los Angeles?

Frank Borden: We have no water cisterns in Los Angeles, and I personally think along with many other people in my field that they are a very important part of our water supply system and should be actually installed along with other things. And a matter of fact, one of the lessons learned from Northridge and Kobe was for our water and power department and the fire department to work together to research the idea of implementing those tanks within our city.

Carole Womeldorf: When the fire trucks are on patrol right after the earthquake, what types of detection methods do you have on the fire trucks to detect fires?

Frank Borden: That may be a good area for research, because we have none other than our eyes and our ears. Some people call it a windshield survey. Many of the Los Angeles police department helicopters and some fire helicopters have infrared capability where they can see on a screen where fires are in total darkness. I think that's something that we need to pursue, at least infrared from aerial operation.

John Rockett: Back in the 1970s, Mission Research did a lot of work with the Los Angeles Fire Department and with the California Division of Forestry primarily directed at the urban brush fire. I wondered if there were any lessons to be learned from these earthquakes which would lead to improvements of those systems.

Frank Borden: Very much so. Thank you for that question. That system that was developed that long ago has evolved tremendously and today, it is a system that is used for all types of incidents. As a matter of fact, the National Fire Academy teaches what we call the incident command system and multiagency coordination, and this is actually occurring all over the country. For the earthquake, this system was applied on a very large scale and worked very well. The state of California has mandated the use of this system because of the Oakland Hills fire and the problems that occurred up there between fire departments and the fact that they weren't using the same systems. So all response agencies in the state of California by the end of this year will be using the incident command system (ICS) and multiagency coordination.

Question: I found in your documents that there is a very precise, very well documented record of individual fire incidence. I was wondering if this was a normal practice that you keep such a record for every fire? And is that record made public?

Frank Borden: Yes. We are hoping that in the very near future a full report on the earthquake including locations and fire problems will be published. I know the department has been working on that. People do have access to fire report records through our department. It costs a person coming in a little bit of money for administrative processing.